
CONTRIBUTED PAPERS

Chinook Salmon Catch and A Preliminary Look at Fish Assemblages in the Sacramento-San Joaquin River Delta and Bays

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Background

Historically, the Stockton Fish and Wildlife Office (STFWO) has used beach seines, Kodiak (KDTR) and mid-water (MWTR) trawls to monitor juvenile Chinook salmon (*Oncorhynchus tshawytscha*) and other juvenile fishes in the Sacramento-San Joaquin Delta and Bays. During the last 6 years, beach seine sampling has been conducted consistently and regularly at 44 sites in 5 regions located in the Sacramento-San Joaquin River Delta and 9 sites in a 6th region, San Francisco and San Pablo Bay. Trawls were conducted at three locations, Chipps Island, Sherwood Harbor, and Mossdale. Data collected by STFWO facilitates decision making and planning for water operations in the Sacramento-San Joaquin Delta and Suisun Bay, and can provide information regarding relative abundance of juvenile fishes.

Here we report the total catch for Chinook salmon and other dominant species by region and gear type for 1 January through 30 April 2005. We also compare the species catch per unit effort (CPUE) as number of individuals/m³, to the previous 5 years of the same reporting period, to determine if an association exists for fish assemblage CPUE over the past 6 years within each sample area. We analyzed these recent data to provide initial insight into the fish assemblage in the Sacramento-San Joaquin Delta and Bays.

Methods

STFWO selected beach seines as a method for sampling near shore communities, and trawls to sample open water from the surface to a maximum depth of 10 feet. To reduce bias in catch from sampling methods, beach seining and trawling were conducted in accordance with standard operating procedures (USFWS 2005). All Chinook salmon captured in beach seine and trawling were assigned a race according to Fisher's size criteria (Fisher 1992).

The STFWO divides the Sacramento-San Joaquin Delta and Bays into 6 different regions each with specific sampling sites (Figure 1): region 1 - Lower Sacramento (7 sites), region 2 - North Delta (10 sites), region 3 - Central Delta (9 sites), region 4 - South Delta (8 sites), region 5 - San Joaquin River (10 sites), and region 6 - San Francisco and San Pablo Bays (9 sites). Between January and April seine sites are sampled once per week with the exception of Lower Sacramento River region, which is sampled twice a week from 1 January through 31 March. An additional 3 sites are sampled during January in the Lower Sacramento River region to improve detection of less abundant races of juvenile salmon, such as winter run.

Trawling is conducted at 3 different locations, Chipps Island, Mossdale, and Sherwood Harbor. STFWO uses only mid-water trawls at Chipps Island and only Kodiak trawls at Mossdale. At Sherwood Harbor, both trawling methods are used: Kodiak trawls are conducted during January through March, while mid-water trawls are conducted during April. STFWO uses Kodiak trawls to increase catch efficiency of larger sized, less abundant races of juvenile Chinook salmon (late fall, winter and spring run) during periods of peak migration (Brandes et al. 2001). Trawls are typically conducted 3 days per week, although their frequency may increase during periods of increased coded wire tag salmon recovery.

To report catch, the juvenile fish monitoring program database maintained by STFWO was queried for all fish species captured between 1 January and 30 April for 2005. All unidentified and non-fish species were excluded. In addition, experimental dyed salmon were excluded from the beach seine calculations because they were released for trawling efficiency experiments conducted by other agencies.

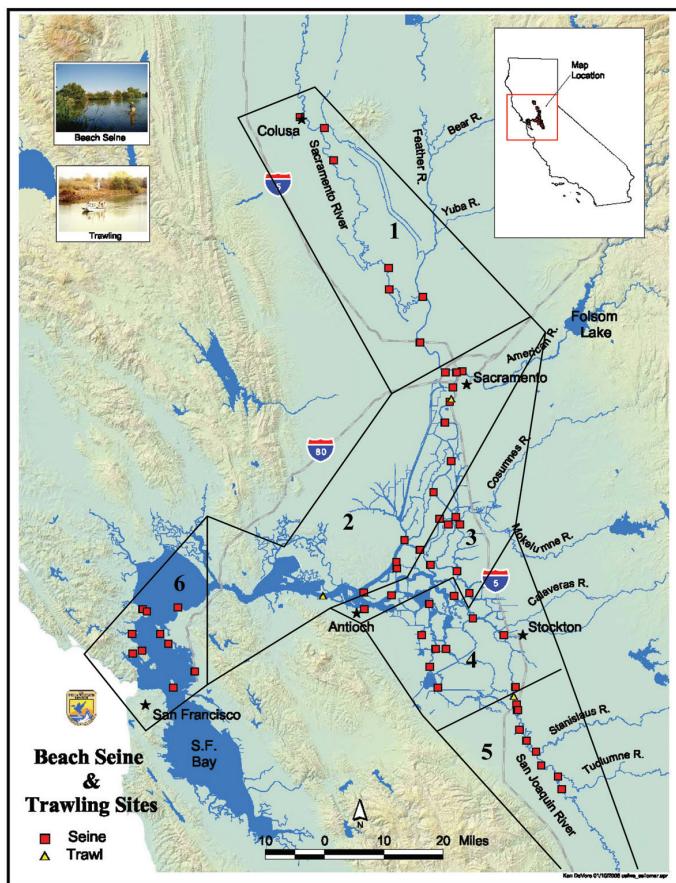


Figure 1 Stockton Fish and Wildlife Office beach seine sites and trawl locations by regions.

Kendall's coefficient of concordance with tied ranks (W_c) (Zar 1999) was selected to compare fish CPUE in specific areas (trawl locations or seine regions) to provide preliminary data regarding fish assemblage stability between 1 January through 30 April from 2000-2005. This test allowed us to compute a correction for tied ranks as well as consider association between several years. To calculate W_c , catch totals and volume of water sampled (effort) were queried from the juvenile fish monitoring program (JFMP) database for the reporting period for the years of 2000-2005, and CPUE were summarized for species by year. For the purposes of calculating W_c , each race of Chinook salmon and marked (adipose fin clipped, tagged, spray-dyed, etc.) salmon were treated as separate species. Marked and unmarked steelhead were also treated as separate species. Ranks from highest CPUE to the lowest were assigned, allowing for ties. Ties within CPUE were accounted for by giving each tie an equal

number. Once all individual species were ranked, we used the following equation to calculate W_c :

$$W_c = \frac{\sum R_i^2 - \frac{(\sum R_i)^2}{n}}{M^2(n^3 - n) - M \sum T^i} \frac{12}{12}$$

where R_i = species rank

n = number of species

M = number of years

$$T = \sum_{i=1}^m (t_i^3 - t_i)$$

t = number of ties

m = number of groups of tied ranks

The value of W_c can range from 0, where there is no association among years within fish assemblage CPUE, and 1 where there is complete association overtime within fish assemblage CPUE.

To determine if the association is significantly different ($\alpha < 0.05$) from a random association, W_c was converted to a Friedman χ^2_r value using the equation below (Zar 1999). Then the calculated χ^2 value was compared to the critical χ^2 distribution.

$$\left(\chi^2_r \right)_c = M(n-1)W_c$$

Results

Chinook Salmon Summary

Between 1 January and 30 April 2005, a total of 9,111 unmarked Chinook salmon were captured while beach seining. The majority of these salmon (Table 1) were fall run captured in region 1, region 2 and region 3. Region 6 (San Francisco and San Pablo Bays) yielded no Chinook salmon during the reporting period. Finally, in regions 1-3, 229 marked salmon were recovered.

STFWO captured 9,031 unmarked (raced juvenile and adult) Chinook salmon while trawling: 5,105 Chinook were captured at Chipps Island; 1,656 at Sherwood Harbor KDTR, 1,822 at Sherwood Harbor MWTR and

448 in the San Joaquin River at Mossdale (Table 2). The majority of marked fish were recovered from Mossdale (Table 2; n = 1,124) in late April and are likely from

experiments conducted by Region 4, California Department of Fish Game (DFG)

Table 1. Regional catch and CPUE of unmarked (raced) and marked Chinook salmon captured from beach seining activities conducted from 1 January - 30 April 2005.

Region	Volume (m ³)	Fall	CPUE	Late Fall	CPUE	Spring	CPUE	Winter	CPUE	Marked	CPUE
1. Lower Sacramento R.	6200.8	2,783	0.448813046	0	0	94	0.015159334	102	60.79215832	89	0.014352986
2. North Delta	9788.3	4,818	0.492222814	10	0.001021633	106	0.010829311	56	0.005721145	74	0.007560085
3. Central Delta	7031.9	1,033	0.146903017	8	0.001137681	50	0.007110504	7	0.000995471	55	0.007821555
4. South Delta	7198.5	21	0.002917274	0	0	0	0	0	0	2	0.000277836
5. San Joaquin R.	2817.6	22	0.007808063	0	0	1	0.000354912	0	0	9	0.003194208
Total		8,677		18		251		165		229	

Table 2. Catch and CPUE of unmarked (raced) and marked Chinook salmon captured at each trawling location from 1 January - 30 April 2005.

Location	Volume (m ³)	Adult	CPUE	Fall	CPUE	Late Fall	CPUE	Spring	CPUE	Winter	CPUE	Marked	CPUE
Chipp's Island mid-water trawl	13884675	0	0	3,374	0.000243	7	5.04153E-07	1,604	0.000115523	120	8.64262E-06	426	3.06813E-05
Mossdale Kodiak trawl	6384041	0	0	139	2.1773E-05	0	0	308	4.82453E-05	1	1.56641E-07	1,124	0.000176064
Sherwood Harbor Kodiak trawl	4218535	1	2.37049E-07	1,507	0.000357233	1	2.37049E-07	98	2.32308E-05	49	1.16154E-05	248	5.87882E-05
Sherwood Harbor mid-water trawl	1009038	0	0	1,409	0.001396378	0	0	412	0.000408309	1	9.91042E-07	205	0.000203164
Totals		1		6,429		8		2,422		171		2,003	

Fish Assemblage - Beach Seining Data

For the reporting period of 1 January through 30 April 2005, 56 different species were captured for a total of 64,417 fish in 754 (est. vol. = 38,700 m³) total beach seine samples. In the lower Sacramento River (region 1), 6,774 fish from 23 species were captured. In the North Delta (region 2), 10,133 fish from 28 species were captured. In the Central Delta (region 3), 6,870 fish from 21 species were captured. In the South Delta (region 4), 8,419 fish from 20 species were captured. In the San Joaquin River (region 5), 25,328 fish from 22 species were captured. In the San Pablo and San Francisco Bay (region 6), 6,893 fish from 17 species were caught. The most abundant fish captured overall were non-indigenous: red shiners (*Cyprinella lutrensis*; n=23,902) and inland silversides (*Menidia beryllina*; n=17,641). Alternatively, the 2 highest catches of native fishes were fall run Chinook salmon (n=8,677) and Sacramento splittail (*Pogonichthys macrolepidotus*; n=2,421). Other priority species captured

were winter run Chinook salmon (n=165) from regions 1, 2, and 3; delta smelt (*Hypomesus transpacificus*; n=18) from region 2, and unmarked steelhead (*O. mykiss*; n=1) also from region 2. As mentioned previously Sacramento splittail were one of the most abundant native species and were found in all regions except 6; though the majority of the individuals were captured in region 3. In 2005, 3 or fewer fish species comprised > 75% of the total fishes captured in each region (Table 3).

Total catch data by region from 2000 and 2004 are included in Table 4. W_c was calculated to assess changes in the ranks of fish within an assemblage between 1 January to 30 April from 2000 - 2005. CPUE of fish assemblages sampled by beach seines were evaluated by regions. Region 1 (Lower Sacramento River) had a high association of W_c=0.8233 (χ^2_r = 182.8; n = 38 species) in CPUE ranks over time. Regions 2, 3, and 4 all demonstrated somewhat high associations, W_c=0.7584 (χ^2_r = 200.2; n = 45 species), 0.7408 (χ^2_r = 146.7; n = 34 spe-

cies), and 0.7624 ($\chi^2_r = 151.0$; n = 34 species), respectively. Region 5 had a value of $W_c = 0.7297$ ($\chi^2_r = 122.6$; n = 29 species). Region 6 had the lowest value for W_c

(0.6927) ($\chi^2_r = 149.6$; n = 37 species). The association of CPUE ranks over time in each region were statistically significant ($p < 0.001$).

Table 3. Species that comprise greater than 75% of the fishes captured within each beach seine region and trawl sample area from 1 January - 30 April 2005.

Beach Seine Region	Species	(n)	% of total fish captured	Total Fish Captured	Total Species
1. Lower Sacramento River (n = 7 sites)	TOTAL	5,109	75%	6,774	23
	Chinook Salmon (fall)	2,783	41%		
	Sacramento Sucker	1,299	19%		
	Inland Silverside	1,027	15%		
2. North Delta (n = 10 sites)	TOTAL	9,136	90%	10,133	28
	Chinook Salmon (fall)	4,818	48%		
	Inland Silverside	4,318	43%		
3. Central Delta (n = 9 sites)	TOTAL	5,337	78%	6,870	21
	Inland Silverside	3,049	44%		
	Splittail	2,288	33%		
4. South Delta (n = 8 sites)	TOTAL	8,035	95%	8,419	20
	Inland Silverside	5,961	71%		
	Red Shiner	2,074	25%		
5. San Joaquin River (n = 10 sites)	TOTAL	21,469	85%	25,328	22
	Red Shiner	21,469	85%		
6. San Francisco and San Pablo Bays (n = 9 sites)	TOTAL	6,687	97%	6,893	17
	Pacific Herring	4,035	59%		
	Topsmelt	2,652	38%		
<i>Trawl Location</i>					
Chippis Island	TOTAL	11,567	77%	15,039	19
	American Shad	6,589	44%		
	Chinook Salmon (fall)	3,374	22%		
	Chinook Salmon (spring)	1,604	11%		
Mossdale	TOTAL	2,011	83%	2,434	23
	Chinook Salmon (marked)	1,124	46%		
	Threadfin Shad	339	14%		
	Chinook Salmon (spring)	308	13%		
	Pacific Lamprey	240	10%		
Sherwood Harbor (mid-water)	TOTAL	1,821	89%	2,039	7
	Chinook Salmon (fall)	1,409	69%		
	Chinook Salmon (spring)	412	20%		
Sherwood Harbor (Kodiak)	TOTAL	1,851	84%	2,216	22
	Chinook Salmon (fall)	1,507	68%		
	Chinook Salmon (marked)	246	11%		
	Chinook Salmon (spring)	98	4%		

Table 4. A summary of species richness and total individuals captured while beach seining and trawling from 1 January - 30 April between 2000 and 2004.

	2000	2001	2002	2003	2004					
	Species Richness	No. Individuals								
<i>Beach Seine Region</i>										
1. Lower Sacramento River	22	8,790	25	6,651	24	8,533	23	9,712	23	13,027
2. North Delta	28	16,057	30	8,737	21	7,281	23	8,721	20	11,241
3. Central Delta	19	4,618	23	4,149	23	4,072	23	5,118	20	5,242
4. South Delta	21	7,037	19	6,313	19	7,172	19	6,143	18	5,470
5. San Joaquin River	15	12,500	13	10,025	13	12,807	15	13,289	16	15,338
6. San Francisco and San Pablo Bays	16	1,227	23	1,470	15	1,381	18	4,645	22	3,470
<i>Trawl Location</i>										
Chiggs Island	25	20,579	27	9,780	25	13,567	19	14,059	23	14,058
Mosssdale	24	2,572	19	3,751	20	4,826	20	6,364	19	4,218
Sherwood Harbor (mid-water)	6	2,285	8	1,845	5	2,943	9	3,118	11	5,258
Sherwood Harbor (Kodiak)	15	3,635	18	5,656	18	2,545	16	2,732	17	3,249

Fish Assemblage – Trawling Data

STFWO conducted 1,932 trawls (est. vol. = 25,496,289 m³) between 1 January and 30 April 2005 and captured 36 different species for a total of 21,740 fish. Chipps Island trawls yielded 19 different species for a total of 15,039 fish. At Mosssdale, 23 different species were captured for a total of 2,434 fish. Sherwood Harbor mid-water trawls captured 7 different species for a total of 2,039 fish and Kodiak trawls captured 22 different species for a total of 2,216 fish. The most abundant species captured overall were non-native American shad (n = 6,590), 99% of which were captured at Chipps Island. Fall run Chinook salmon (n = 6,429) were the most abundant native species overall and were captured at all trawling locations, although they did not represent a large proportion of the total catch at Mosssdale. Some species of concern to IEP that were captured while trawling include: Sacramento splittail (n = 345) captured at Chipps Island, Mosssdale, and Sherwood Harbor (Kodiak gear); Delta smelt (n = 247) captured at all locations and gear types; and unmarked steelhead (n = 18) captured at Chipps

Island and Sherwood Harbor (both gear types). Winter run Chinook salmon (n = 171) were captured at all locations and gear types; however, the one specimen detected at Mosssdale is likely a large fall run Chinook salmon. In 2005, as reported for the beach seine data, 3 or fewer fish species comprised > 75% of the total fishes captured at each trawl location (Table 3).

W_c was calculated to assess changes in the ranks of the CPUE between 1 January to 30 April from 2000 - 2005. Each trawling site and year combined was treated as an assemblage. The strongest association of CPUE for the fish assemblage occurred at Chipps Island (W_c = 0.79; χ^2_r = 210.0; n = 45 species). Mosssdale (W_c = 0.77; χ^2_r = 165.8; n = 37 species), Sherwood Harbor MWTR (W_c = 0.73; χ^2_r = 96.2; n = 23 species) and Sherwood Harbor KDTTR (W_c = 0.73; (χ^2_r = 143.7; n = 34 species) had somewhat high W_c values. A significant association for CPUE of fish species over time existed at each trawling location (p < 0.001).

Discussion

Using abundance ranks by species (Kendall's W_c) is a broad ecological approach and an excellent way to preliminarily examine inter-annual fish assemblage stability. The relatively high Kendall's W_c values show that if a species CPUE for 2005 had a high rank (more abundant) then it is very likely that the same species had high relative abundance in each of the previous 5 years. The same is true for mid and low ranked species (ie., ranks for species within an assemblage are not changing greatly during the study period). This lack of change in ranks indicates that, (from January to April), there is stability within the fish assemblage for each region or location over the past 6 years. All associations were found to be statistically significant indicating that the stability in the ranks is not random. The relatively high catches of Chinook salmon and rank consistency across years indicate that the standard operating procedures and current survey gear are relatively effective at capturing salmon from year to year.

Although the overall dynamics of the fish assemblage appear to be stable, it is likely that the most abundant species caught are highly influencing the analysis. For example: large numbers of Chinook salmon may influence stability in region 1 and 2 while the continued presence coupled with the high abundance of red shiners may influence stability in region 5. In future analysis, investigating the association among years without the dominant species may show different results. Also, a more in depth look at native and non-native dynamics between years may provide insight into assemblage stability. Based on this analysis, it would be worthwhile to compare assemblage changes across years, since the inception of the program, to analyze the possible affects of biological (non-native species) and physio-chemical parameters to the native fish in the assemblage.

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